THE CASE FOR CONCERN ABOUT VERY LOW FREQUENCY FIELDS FROM VISUAL DISPLAY TERMINALS: THE NEED FOR FURTHER RESEARCH AND SHIELDING OF VDTs

BY

KAREL MARHA
BARRY SPINNER
JIM PURDHAM

CANADIAN CENTRE FOR OCCUPATIONAL HEALTH AND SAFETY

HAMILTON, ONTARIO
APRIL 22, 1983

P83-2E

88-06165/

THE CASE FOR CONCERN ABOUT VERY LOW FREQUENCY FIELDS FROM VISUAL DISPLAY TERMINALS: THE NEED FOR FURTHER RESEARCH AND SHIELDING OF VDTs

CCOHS NUMBER P83-2E

ISBN 0-660-11440-2

DSS CATALOGUE NUMBER CC273-2/83-2E

This publication is available
in both official languages.

Cette publication est disponible
dans les deux langues officielles.

While the Centre endeavours to ensure the accuracy and completeness of information provided, it is understood that the Centre makes no warranty as to the accuracy or completeness of such information and assumes no liability for any damages or loss suffered as a result of any inaccuracy or incompleteness therein.

Published 1983

Additional copies available upon request.

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

Much concern has been expressed by users of the Canadian Centre for Occupational Health and Safety's Information and Advisory Service about the risks to operators of visual display terminals. Inquirers focus their attention particularly upon two items: the risks of adverse pregnancy outcome and the possibility of radiation emissions from visual display terminals, both ionizing and nonionizing. In large part, these concerns have arisen following the reports of so-called "clusters" of birth defects and spontaneous abortion amongst operators of visual display terminals. In some inquirers' minds the radiation issue and these clusters are linked; nowever, a number of explanations have been put forward for the occurrence of these phenomena which include radiation, stress, ergonomic factors, and chance. As a consequence of the concerns expressed by inquirers to CCOHS, the evidence concerning electromagnetic radiation emitted from visual display terminals was collected and evaluated.*

It has become apparent that the radiation conventionally considered most suspect, X rays produced in the cathode-ray tube, should not represent a significant source of risk, since published measurements show that the degree of exposure associated with operation of visual display terminals is negligible. Similar findings were obtained for portions of the nonionizing radiation spectrum particularly ultraviolet, visible, infra-red, and microwaves. The attempts to measure X rays and these other emissions from VDTs, the biological effects and subsequent risk assessments have been studied and published elsewhere. However, one portion of the electromagnetic spectrum, that known as the very low frequency spectrum occurring between 3 and 30 kilohertz, has not had the same attention. Consequently, this area was examined closely. It was found that while the evidence could not in any way be considered to constitute proof of harm, it did show that there was cause for concern. The evidence for this concern is the subject of this paper.

---

*On January 11, 1983 a CCOHS scientific group including the President issued a press release concerning this topic.

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

2 / Concern for VLF Fields

That evidence is considered under four headings:

1. Evidence of pulsed very low frequency (VLF) electromagnetic fields from visual display terminals.

2. Evidence of biological effects of pulsed electromagnetic radiation.

3. Evidence of detrimental effects of pulsed electromagnetic radiation.

4. Evidence of the effectiveness of shielding.

A fifth section deals with prevailing standards for this type of radiation.

Evidence of Fields from VDTs

1. What are the characteristics of the very low frequency electromagnetic fields from VDTs?

These fields have both electric and magnetic components. They are highly directional, depending on the design and shielding characteristics of the equipment. The nature of the production and propagation of the fields causes them to be pulsed with a repetition frequency dependent upon technical factors (such as line frequency, 60 hertz). The pulse duration is of the order of 4 to 9 microseconds. The frequency range of concern is 15,000 to 30,000 hertz [appendix 1] which is in the VLF band, 3,000 to 30,000 Hz.

2. What evidence is there for their presence around VDTs?

The physical design of the electronics utilizing a horizontal oscillator "flyback" transformer results in fields being produced. These are measurable outside the equipment: the magnitude depends upon the effectiveness of the incidental shielding of the equipment. Measurements of these fields have been made by competent people in a number of national regulatory bodies using reliable equipment. Results of these measurements have been reported by the Bureau of Radiological Health in the United States(1) [appendix 2], the National Radiological Protection Board (NRPB) for the Health and Safety Executive in Great Britain(2) [appendix 3], and the Radiation Protection Bureau in Canada(3) [appendix 4]. In addition, there have

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

been reports from Ontario Hydro's Research Division(4) [appendix 5] and a British firm consulting for the NRPB(5) [appendix 6]. There have also been reports of fields of varying magnitudes from several other sources; however, the measurement procedures used make these reports less reliable than those cited above(6).

3. What measurements have been reported for these fields?

The fields are found to be highly directional depending upon the design [e.g. appendix 7]; therefore, measurements of magnitude have to be reported with respect to position. From this fact, it is evident that the exposure of other people near the VDT can be higher than the exposure of the operator [appendix 8]. This means that measurements have to be made at 10 - 30 cm from all surfaces, not just in front of the screen. Unfortunately, the bulk of measurements have been reported only in front of the screen. The range of measurements may vary from zero (negligible) to in excess of 300 volts per metre for measurements made 10 - 30 cm from a surface.

Evidence of Biological Effects

Biological effects of pulsed electromagnetic radiation relative to continuous (CW) radiation have been extensively studied. However, specifically in the VLF band, we have not been able to find any published comparisons, due to the fact that the VLF band has been studied very little. At least thirteen different effects have been noted from pulsed microwaves(7). This information was summarized by Postow who arrived at the general conclusion that pulsed electromagnetic radiation qualitatively had more biological effectiveness than continuous radiation. That is, the pulsed electromagnetic radiation generally interacts more with biological matter than continuous radiation. Most of the research was radar-related. One must note that it is actually very difficult to distinguish whether it is the actual carrier frequency that is responsible for the effects, or the modulating frequency. The modulating frequencies used for radar occur in the extremely low frequency (ELF) band, that is, at frequencies less than 3,000 hertz. Again, there is evidence for biological effects at these frequencies: the Pafkova paper(8) [appendix 9] dealing with birth abnormalities in mice; a Swedish paper dealing with damage to blood cells(9), published work on audiogenic epilepsy(10) and a number of publications dealing with theoretical background for therapeutic medicine where pulsed extremely low frequency was used in the healing process(11).

CCOHS/CCHST
Hamilton, Ontario, Canada

In summary, the evidence shows that pulsed electromagnetic radiation has more biological effectiveness than continuous electromagnetic radiation. Effects have been noted at frequencies both higher and lower than the region of concern and at magnitudes both higher and lower than those observed around VDTs.

Evidence of Detrimental Effects

At this time, the significance of many of the possible detailed effects is unknown(12). However, some of the effects described in the experimental literature are clearly detrimental. Included amongst these are birth abnormalities in mice as described in the Pafkova paper(8) and detrimental effects upon blood cells(9,19).

A theoretical work was published demonstrating the possibility of highly irregular distribution of an alternating signal along the cell membrane(13). Further research is needed to examine the conditions under which this effect could result in the development of a potential gradient across the cell membrane high enough to damage the cell.

We should emphasize that there is no direct evidence of biological effects of fields from VDTs. Also, to our knowledge, there is no published work which shows the absence of any effects. Simply, there has been no systematic attempt to study the possible effects of such exposure. We are well aware of the most commonly reported effects--the ergonomic, the visual, the postural and the stress-related. There has been a report from Sweden of a systematic study which found a change in catecholamine and triglyceride levels in VDT operators(14). One cannot say that these changes are due to the EM field.

Because of the points developed above, that is, (a) the suggested evidence (cited above) for the possibility of biological effects, and (b) the gap in our knowledge about this particular frequency range, we are encouraging additional research on these questions.

Since that research will be some time in providing answers, the intermediate step of minimizing the field by shielding the source ought to be pursued.

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

Evidence of Effectiveness of Shielding

A number of reports explicitly demonstrate the effectiveness of shielding whether it was incidentally installed or not.

For example see (4) [appendix 7] or (15) and (1), p 12 [appendix 10].

Existing Standards and Exposure Limit Values

The only standards actually applicable to the VLF band (3,000 to 30,000 Hertz) are the ACGIH TLV recommendation(16) and US Air Force Standards(17).

Other standards, applicable to bands above 10,000 hertz, are valid in the United States, Czechoslovakia and the USSR. In Ontario guidelines labelled "for discussion only" have been produced.

The maximum permissible exposure limits are summarized in (18); see also appendix 11.

In appendix 12 comparison is made of some of these standards to measured fields near VDTs(18).

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

REFERENCES

1. An evaluation of radiation emission from video display terminals. (HHS Publication FDA 81-8153). Rockville, Md.: U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration, Bureau of Radiological Health, 1981

2. Cox, E.A. Radiation emissions from visual display units. In: Health Hazards of VDUs? 1. Papers presented at a one day conference on Thursday 11th December, 1980 at Loughborough University of Technology. Loughborough, U.K.: HUSAT Research Group, Department of Human Sciences, Loughborough University of Technology, 1980]. p. 25-36

3. Stuchly, M.A.; Lecuyer, D.W. Electromagnetic emissions from video display terminals. Presented at 5th Annual Scientific Session of the Bioelectromagnetics Society. Boulder, Colorado : June 12-17, 1983

4. Harvey, S.M. Characteristics of low frequency electrostatic and electromagnetic fields produced by video display terminals. (Ontario Hydro Research Division, Report No. 82-328-K). Toronto, Ont. : Ontario Hydro 1982

5. In: E.A. Cox (1980). Reference [2]

6. Weiss M.M.; Petersen R.C. Electromagnetic radiation emitted from video computer terminals. American Industrial Hygiene Association Journal. Vol. 40, no. 4 (1979). p. 300-309

7. Assenheim, H.M.; Hill, D.A.; Preston, E.; Cairnie, A.B. The biological effects of radio-frequency and microwave radiation. (NRCC No. 16448) Ottawa : National Research Council of Canada, 1979

8. Pafkova, H. Sledovani Embriotropniho Ucinku Elektrostatickeho Pulsniho Pole [in Czech] = Following the embryotropic effects of pulsed electrostatic fields. Pracovni Lekarstri. Vol. 32, no. 10 (1980). p. 334-338

9. Hild, K.H.; Lövdahl, L.; Lövstrand, K. G.; Lovtrup, S. Effect of high-voltage pulses on the viability of human leucocytes in vitro. Bioelectromagnetics. Vol. 3 (1982). p. 213-216

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

10. Stverak, I.; Marha, K.; Pafkova, H. Some effects of various pulsed fields on animals with audiogenic epilepsy. In: Biological effects and health of microwave radiation. Proceedings of an International Symposium. Warsaw: 15-18, October 1973. p. 141-144

11. Luben, R.A.; Cain, C.D.; Chen, M.C.; Rosen, D.M.; Adey, W. R. Effects of electromagnetic stimuli on bone and bone cells in vitro : inhibition of responses to parathyroid hormone by low-energy low-frequency fields. In: Proceedings of the National Academy of Sciences. Vol. 79 (1982). p. 4180-4184

12. NIOSH planning reproductive study of VDT workers. Microwave News. Vol. 2, no. 9 (1982). p. 1

13. Marha, K.; Musil, J. The cell as an electric circuit-I. Theoretical study and the cell as an electric circuit-II. Experimental section. Biofizika. Vol. 22, no. 5 (1977). p. 816-823

14. Johansson, G.; Aronsson, G. Stress reactions in computerized administrative work. Stockholm : Department of Psychology, University of Stockholm, 1980

15. Potential health hazards of video display terminals. Cincinnati, Ohio : NIOSH, 1981. p.29

16. TLVs threshold limit values for chemical substances and physical agents in the workroom environment with intended changes for 1982. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1982

17. Mitchell, J.C. Review of radiofrequency radiation exposure standards. Aeromedical Review. No. 3 (1981). p. 7-19

18. Marha, K. The state of knowledge concerning radiation emissions from video display terminals. (Presented at Science Focus, Ottawa, Ontario on October 6, 1982). Hamilton, Ont. : Canadian Centre for Occupational Health and Safety (CCOHS), 1982

19. Cleary, S.F.; Hoffman, R.; Liu, L. Investigation of the biological effects of pulsed electrical fields. Report 30. January 1977. NTIS AD-A091813/6

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

LIST OF APPENDICES

APPENDIX 1 Pulsed Modulated Waveform

APPENDIX 2 Nonionizing Radiation Data From Selected VDTs

APPENDIX 3 Summary of Radiation Measurements on VDUs

APPENDIX 4 Maximum Intensity of Electric Field and its Location in the VDT for Various Models

APPENDIX 5 Summary of Electric Fields Measured at a Grounded Conducted Surface 30 cm From the CRT Screen Units

APPENDIX 6 Summary of Radiation Measurements on VDUs, Electrical Research Association Technology Limited

APPENDIX 7 Field Strengths Around a VDT

APPENDIX 8 Locus of Constant Pulsed Field

APPENDIX 9 Following the Embryotropic Effect of Electrostatic Field, Pracovni Lekarstvi

APPENDIX 10 Effectiveness of Shielding

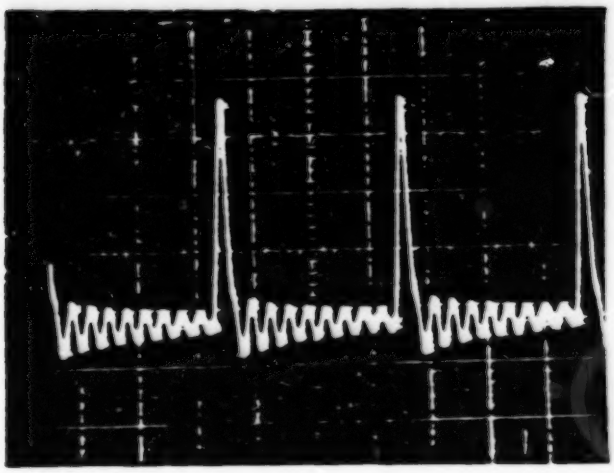
APPENDIX 11 Some Standards Covering the Very Low Frequency or the Low Frequency Range

APPENDIX 12 Measurements of EMR Compared to Various National Standards

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 1

PULSED MODULATED WAVEFORM



Waveform of 15.9 kHz Pulsed Field
Horizontal Scale is 20 μs/div.
T = 62.9 μs; Pulse duration = 9 μs

Source: Harvey, SM; figure B6; see reference (4).

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 2

NONIONIZING RADIATION DATA FROM SELECTED VDTs

VDD TEST REPORT - NONIONIZING RADIATION 09 JUL 80

MFR[1]	MODEL TESTED	TEST DATE	OPT RAD[2] BARE DETECTOR W X 10-6	OPT RAD[3] RADIOM FILTER W X 10-6	OPT RAD[4] UV-360 FILTER W X 10-6	BOR[5] RATE KHZ	LTRASOUND[6] DB AT FREQ (D = 20 IN)	ULTRASOUND[7] DB AT FREQ (CAB SURF)	RF[8] MAGNETIC A/M (D = 2 IN)	RF[9] ELECTRIC V/M (D = 2 IN)	RF[10] ELECTRIC V/M (D = 12 IN)
ADSY	TV-5	800324	20	10	.036	15.75	59016	91016			120
							42031.5	63031.5			
AUVI	900949	800215	0.92	0.45	0	15.0	0	0			
							58031.5	54031.5			
AUVI	951-01	800331	0.93	0.43	0.00	15	55016	89016			200
							40031.5	69031.5			
AUVI	940-04(2)	800521	1.3	0.57	0.0	15.2	61016	87016		89	4
							44031.5	60031.5			
BOSI	MC37BB	800220	0.9	0.4	0.0	15.0	49016	81016			
							33031.5	50031.5			
BUNK	549272	790911	20.0	9.4	0	20	56020	73020			
							44025	49025			
CNUO	QDM-9M	800606	5.2	2.5	0.000	15.75	53016	72016		35	4.3
							46031.5	56031.5			
CNUO	QDM-12K	800606	5.8	3.0	0.000	15.75	45016	76916		55	6.7
							44031.5	68031.5			
CINE	VBS-3	800116					0	0			
							0	0			
COCO	5211/C19	800604	9.0	4.0	0.009	15.75	61016	90916		280	45
							54031.5	73031.5			
CODA	CC-115A	790920	5.6	2.6	0	35	51016	77016			
							44931.5	59031.5			
COMO	8277	791011	1.5	0.6	0	23	<30020	61020			
							42925	70925			
ELST	DM10-09AD	790628	6.5	3.2	.008	17	48016	76016			
							38031.5	52031.5			
ELST	DM20-12AD	790926	5.4	2.4	.002	16	0	0			
							0	0			
FOUR	7101	790719	1.7	.08	0	16	53016	73016			
							0	0			
FOUR	7111	800122	1.8	0.8	0	15	0	0			
							0	0			
FOUR	5115/7111	800610	2.4	1.0	0.0	15.75	50016	66916			100
							42031.5	36031.5			
HITA	CD-12	800320	5.6	2.8	0.001	15	41016	54016			
							36031.5	61031.5			
IBMC	3278-2	800409	0.55	0.25	0.00	15	28010	32916			
							30831.5	48831.5			
IKEG	PM-950	800201	5.8	2.9	0.003	15	43016	69916		180	11
							42931.5	70931.5			
LEXI	VT112	790821	.61	.28	0	22	0	0			
							0	0			
MICO	D3910(2)	800606	3.0	1.4	0.004	15.75	56016	85916		80	6.5
							53031.5	68031.5			
MOHD	2491	800110	0.5	0.25	0	15	0	0			
							0	0			
NESI	FVM-95A	800603	2.9	1.4	0.000	15.75	58016	79016		120	4
							52031.5	67031.5			
ONTE	OP-1/R	800428	9.5	4.6	0.0	19.2	46020	62920		140	10.5
							48040	60940			
ONTE	OP-1	800509	0.53	0.25	0.00	20	51020	64020	0.69	64	2.4
							45940	63040			
REDA	V591-6022	790919	.96	.43	0	30	3506.3	4106.3			
							43031.5	72031.5			
TECP	2277 MARKII	800428	4.8	2.4	0.00	20	51020	68920			270
							53040	69040			
TECP	2277	800425	6.6	3.3	0.005	20	65020	97020	0.65	28	2.4
							68040	79025			
VYDE	1400	790807	9.6	4.5	0	2	<3008	4308			
							42040	59040			
WANG	12WP	791120	9.6	4.45	0	16	0	0			
							0	0			
WGEC	19V10C1(1)	790702	5.0	2.5	0.004	16	0	0			
							0	0			
ZERC	D12PF-1	791029	7.6	3.8	0.015	18	0	0			
							0	0			
ZERC	D12-NF-1	800603	10.0	5.0	0.000	15.75	43016	68916		>300	21
							47031.5	79031.5			

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

1. Refer to Appendix A [see reference (1)] which lists the full manufacturer name for each code.

2. Optical radiation measured with bare (unfiltered) detector. This value is given in microwatts.

3. Optical radiation measurement with radiometric filter in place. This value is given in microwatts.

4. Optical radiation measured with ultraviolet filter in place. This value is given in microwatts.

5. Horizontal (scanning) frequency in kilohertz.

6. Measured amplitude of sound in decibels at a distance of 20 inches from the VDT surface. The top numbers refer to the maximum measured amplitude in the frequency ranges centered on 20 kilohertz or lower and the frequency at which this amplitude was observed. The lower numbers indicate the maximum measured amplitude in the frequency ranges centered on 25 kilohertz or higher.

7. Measured amplitude of sound in decibels at the surface of the VDT.

8. Magnetic (H) field of radiofrequency radiation measured in amperes/meter at a distance of 2 inches from the VDT surface.

9. Electric (E) field of radiofrequency radiation measured in volts/meter at a distance of 2 inches from the VDT surface.

10. Electric (E) field of radiofrequency radiation measured in volts/meter at a distance of 12 inches from the VDT surface.

Source: An evaluation of radiation emission from video display terminals; appendix D, p. 34-35; see reference (1).

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 3

SUMMARY OF RADIATION MEASUREMENTS ON VISUAL DISPLAY UNITS

Electromagnetic Spectrum Region	Maximum Measured Emission	Measuring Instrument	MPEs, MELs TLVs etc	Standard	Remarks
X rays λ<100 pm	Dose equivalent rate <10 μrem hr^{-1}	Victoreen 440 RF/C	0.5 mrem hr^{-1}	BS 415 : 1979	Photon energy >10 keV
Ultraviolet 240-336 nm 336-440 nm	Irradiance 0 124 Wm m^{-2}	HRPB Scanning Spectral Radiometer (SSR)	--- 10 Wm^{-2}	ACGIH	Endorsed by NRC (private communication)
Visible 400-700 nm	Irradiance 2.5 Wm^{-2} Calc. radiance 0.8 Wm^{-2} sr^{-1}	EG & G Type 550 radiometer or UDT 40X optometer (with filters)	21C_3 $Wm^{-2}sr^{-1}$	Draft IEC/TC76 Draft BS 4803	MPEs for viewing laser by diffuse reflection C_3=1 for λ=400-500 nm log C_3=0.015 (λ-550) for λ=550-700 nm
Infrared (near) 700-1050 nm	Irradiance 50 Wm m^{-2}		100 Wm^{-2}	ACGIH	Intended TLV
Infrared (far) 10 μm-3 mm	4 Wm^{-2}	Plessey pyroelectric detector	---		Measured irradiance equivalent to thermal radiation from body at 32°C. No measurable non-thermal radiation.
Microwave and radiofrequency 18 GHz-300 MHz	5 Wm^{-2}	Narda 8300	100 Wm^{-2}	ACGIH	See Table 2 for detailed measurements in region.
3 GHz- 10 MHz	<1000 Wm^{-2}	Rahan 12	10 Wm^{-2}	79-EED-30	Spurious measurement. Not confirmed by ERA scan (Table 2)
220 MHz- 10 kHz	Electric field intensity >300 Vm^{-1}	IFI EFSI	60 Vm^{-1} 1500 Vm^{-1} 3000 Vm^{-1}	79-EED-30 Draft foreign Draft foreign	220 MHz-10 MHz 30 MHz- 3 MHz 3 MHz-10 kHz

Source: Cox, EA; Table 1: see reference (2).

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 4

THE MAXIMUM INTENSITY OF THE ELECTRIC FIELD AND ITS LOCATION IN THE VDT FOR VARIOUS MODELS

Field Intensity	No. of Models	Location of Various Field Intensities Number of Models			
		Screen	Top	Sides	Back
Below 5 V/m	10	5*	0	0	0
5-60 V/m	22	19	1	2	0
60-200 V/m	10	7	0	2	1
Above 200 V/m	15	3	5	5	2

*For five models the field intensity was below the instrument sensitivity.

Source: Stuchly, MA; Table 2; see reference (3).

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 5

SUMMARY OF ELECTRIC FIELDS MEASURED AT A GROUNDED CONDUCTED SURFACE 30 cm FROM THE CRT SCREEN UNITS
VOLTS PER METRE (V/m)

	VDT Unit			
	1	2	3	4
dc Fields, About One Half Hour After Turn-on	6000	7000	7000	6000
Maximum Modulation Amplitude, rms (Normal Brightness)	60	65	25	30
16 kHz Pulse Peak Amplitude	55	170	23	19
Approximate rms Amplitude	10	30	5	3
Other Fields, rms Amplitudes	<0.1	<0.1	<0.1	<0.1

Note: Table 1 in the paper by Harvey used V/cm, where we have expressed the measurements in V/m.

Source: Harvey, SM; Table 1; see reference (4).

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 6

SUMMARY OF RADIATION MEASUREMENTS ON VISUAL DISPLAY UNITS BY ERA (MICROWAVE AND RADIOFREQUENCY)

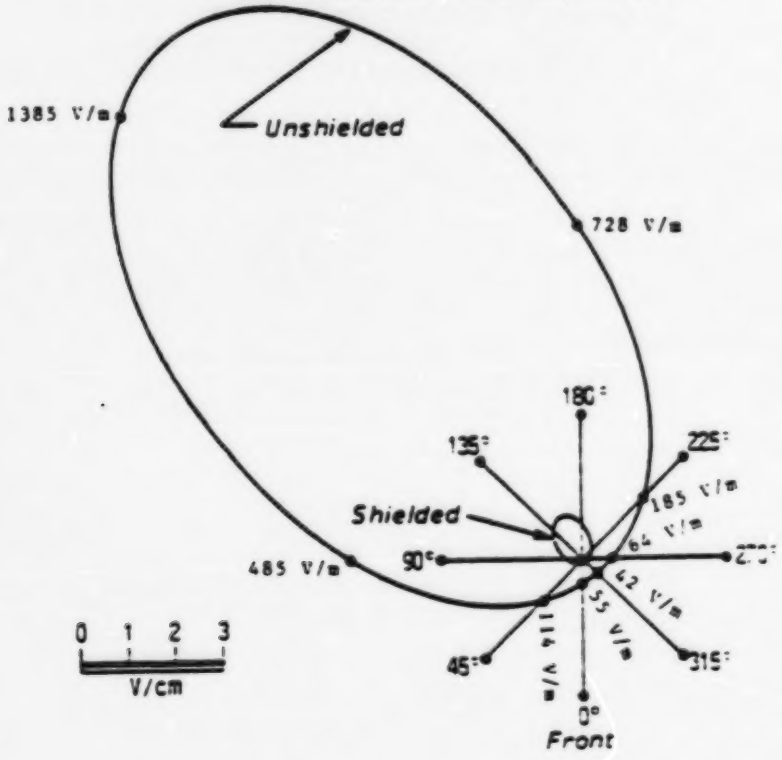
Electromagnetic Spectrum Region	Maximum Measured Emission	Measuring Instrument	MPEs, MELs TLVs etc	Standard	Remarks
Microwave and Radiofrequency	Electric Field Intensity ($V\ m^{-1}$)		($V\ m^{-1}$)		
300 GHz- 30 GHz	Not measured		200	ACGIH	Endorsed by NRC 70/1314 (200 $V\ m^{-1}$ = 100 $W\ m^{-2}$ in free space)
30 GHz- 1 GHz	Not measured				
1 GHz-300 MHz	<0.01	Schwartzbeck VUME 1520A	200	Draft Foreign	To be published for comment
300 MHz- 30 MHz	0.18				
30 MHz- 10 MHz	0.12	Schwartzbeck FSME 1515	60	79-END-30	Canadian standard for general public
10 MHz- 3 MHz	0.5		1500	Draft Foreign	
3 MHz-300 kHz	16				
300 kHz-150 kHz	600				
150 kHz- 10 kHz	1800	Stoddart NM12AT	3000	Draft Foreign	

Source: Cox, EA; Table 2; see reference (2).

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 7

FIELD STRENGTHS AROUND A VDT



Polar Diagram of Pulsed Peak Field Strengths
in Horizontal Plane

Source: Harvey, SM; Figure B7, see reference (4).

Notes by Karel Marha in reference to Figure B7 from the Appendix of the Ontario Hydro Research Division, "Characteristics of low-frequency electrostatic and electromagnetic fields produced by video display terminals," No. 82-528-K.

1. Electric field strengths in the RF band is normally expressed in units of V/m rather than V/cm.

2. 1V/cm = 100 V/m.

3. 7mm = 1V/cm (100 V/m) according to the given scale on this f: ;ure.

CCOHS/CCHST
200 Main Street E./200 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

4. The given points on the ellipse correspond to measured field strengths in a constant distance from the vertical axis of the measured unit. The point at 0° direction is 30 cm from the screen. This means approximately 45-50 cm from the vertical axis of the unit. (My guess)

5. The position of every point on the ellipse states:

   a. Where it was measured - in the graph the VDT is placed in the centre of the directional cross, e.g. 0° (front), meaning the operator's position, 90° means left of the unit, 180° behind the terminal and so on.

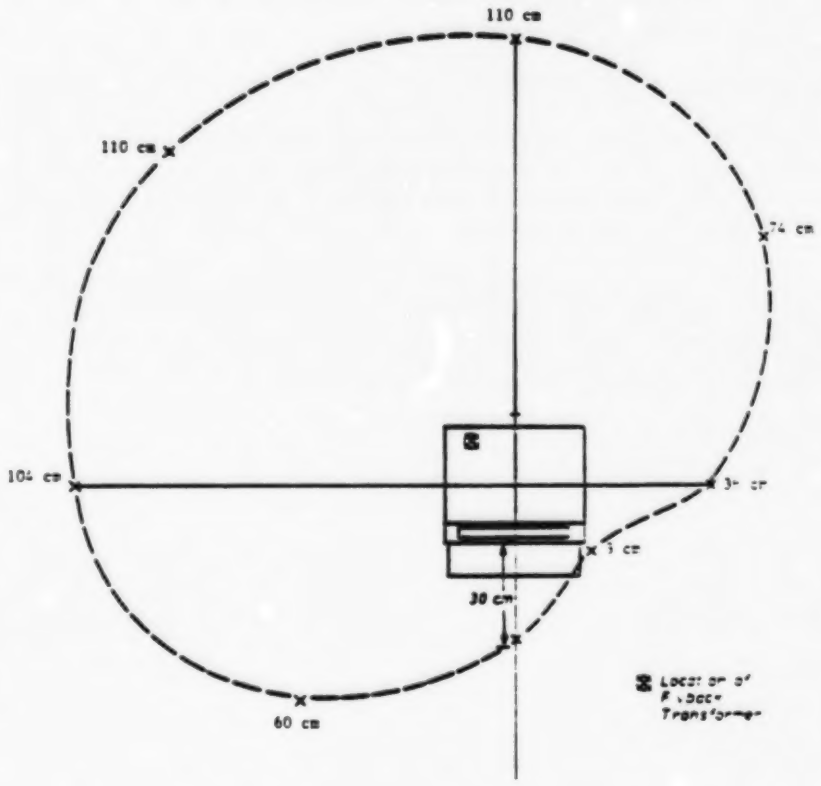
   b. The field strength - from the distance between the point and the center of the cross, n, (in millimetres) we can estimate the field strength E in volts per metre from the equation. $E = \frac{100n}{7}$ [V/m; mm]

6. I added to every point the found field strength, estimated as mentioned above.

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX B

LOCUS OF CONSTANT PULSED FIELD



Locus of Constant Pulsed Field
(0.55 V/cm Peak to Peak)

Source: Harvey, SM; Figure B8; see reference (4).

Calculations and additions by Karel Marha: The distance from the nearest surface of the measured VDT was calculated from the equation:

$$\ell = \frac{30n}{25}$$

where n is the shortest distance (in mm) between the given point X on the dashed line and the VDT surface.

The distance, estimated as mentioned above, are noted at every point on Figure.

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 9

FOLLOWING THE EMBRYOTROPIC EFFECT OF ELECTROSTATIC FIELD

The embryotropic effect of electrostatic pulse field (amplitude 1000 V, gradient of the field 285 V/cm, pulse band 10 μs, repeating frequency 300 Hz) chronically applied from day 1 to day17 of pregnancy was followed from the point of view of higher biological efficiency of pulse fields in laboratory mice. The course of pregnancy, number of dead fetuses, conditions of the placentae and fetal membranes, conditions, size and weight of thematurefetuses and conditions of their internal organs were evaluated. Significant changes found in the exposed group indicate an unfavourable effect of electrostatic pulse field on embryonic development, particularly in the early stages of life.

Source: Pafkova, H; pp 334-338; see reference (8).

Comments by Karel Marha: The averaged field was 85 V/m. Twenty-three females were used in the experimental group: 21 in control groups.

The fertility before the experiment was the same in both groups. The results, in the experimental group against control group:

Preimplantation resorption:	240% higher (P-0.01)
Postimplantation resorption:	160% higher (P=0.05)
Late resorption:	470% higher (P=0.01)
Dead fetus:	525% higher (P=0.01)

The total number of living offspring in control group was 272, and in experimental, 230. Of offspring born live there were: a statistically insignificant higher number of haematomas on the body surface, and one case with deformation of extremities (statistically insignificant).

However, there was a higher number of dwarfish offspring (about 310%, P=0.05) and about 310% higher number with unclosed eyelids.

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 10

EFFECTIVENESS OF SHIELDING

Location	Distance cm	E-field ADA 10/A V/m	E-field EFS-1 V/m	H-field A/m
CRT Face Center (Radial)	5	28	64	0.69
	30	0.3	2.4	0.008
Above High Voltage Transformer* (Shield removed)	5	88	>1000**	0.06
	19		300	0.06
Above High Voltage Transformer (Shield in place)	5	0	0	0.06

Field Strength Magnitude
Ontel Model OP-1/32k/50 S/N 14689

* This was done to determine the shielding effectiveness of the metallic-coated cover of this unit and to simulate concentrated area conditions. It also provided verification that the E-field sensors did not respond to magnetic fields in this location.

** See para. 4.3.2. in Refernce (1).

Source: An evaluation of radiation emissions from VDTs, BRH Table 2, p 12; see reference (1).

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 11

SOME STANDARDS COVERING THE VERY LOW FREQUENCY OR THE LOW FREQUENCY RANGE

US Air Force	10kHz	-	10MHz	435V/m
ACGIH	10kHz	-	3MHz	600V/m**
Czechoslovakia	30kHz	-	30MHz	50V/m*
USSR	60kHz	-	3MHz	50V/m*
Bulgaria	60kHz	-	3MHz	50V/m*
German Democratic Republic	60kHz	-	3MHz	50V/m*
Canada (Ontario)	300kHz	-	300GHz	60V/m***
ANSI	300kHz	-	3MHz	600V/m**

* Standards in the workplace. The values for the general public are often even more stringent (e.g. in Czechoslovakia, for 8 hours it is 15V/m).

** At a distance of 5 cm from any point on the device's surface.

*** "For discussion only" guideline.

ANSI American Standards Institute (approved as an American National Standard on July 30, 1982).

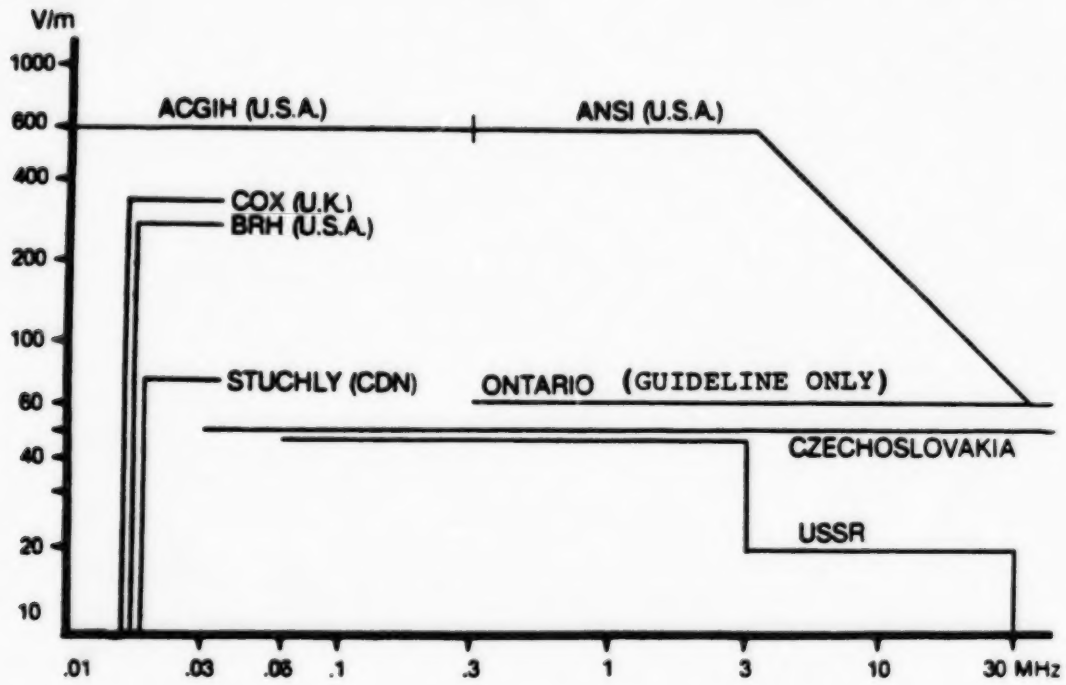
ACGIH American Conference of Governmental Industrial Hygienists.

Source: Marha, K; Table 3, p 8; see reference (18).

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6

APPENDIX 12

MEASUREMENTS OF EMR
COMPARED TO VARIOUS NATIONAL STANDARDS



Source: Marha, K, see reference (18).

CCOHS/CCHST
250 Main Street E./250 rue Main est.
Hamilton, Ontario, Canada L8N 1H6